JP3.4 VARIABILITY OF FRESHWATER FLUX DERIVED FROM SATELLITE DATA

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1.INTRODUCTION

Understanding water cycle is critical for our life. However, it has been difficult to estimate freshwater flux over the ocean by using ocean observation data because the number of in situ ocean observation data is extremely small and the distribution is inhomogeneous. On the other hand, satellite data are characterized by the high density, the high resolution and the homogeneity. Therefore, it can be considered that we obtain more accurate fresh water flux over the ocean by using satellite data. Recently we constructed surface latent heat flux data set mainly using satellite data. The data set is included in Japanese Ocean Flux data sets with Use of Remote sensing Observations (J-OFURO) (Kubota et al.,2002). Moreover, Tropical Rainfall Measuring Mission (TRMM) provides useful precipitation data in the tropical region. We can estimate freshwater flux data from above-mentioned two data sets.

In this study we estimated precipitation, evaporation and freshwater flux over the tropical ocean and applied EOF analysis to those flux data.

2. DATA

The data used in this study are monthly mean fields for the period from 1998 to 2000. The data are on a 1° x 1° latitude-longitude grid.

2.1 Evaporation data over the ocean

We derived evaporation data over the ocean from J-OFURO latent heat flux data.

2 Precipitation

We estimated monthly precipitation by averaging TRMM/3G product data which are originally hourly data on 0.5° x 0.5° grid. The data exist not only over the ocean but also over the land. DMSP/SSMI and Reynolds SST data are used for estimation of J-OFURO latent heat flux data.

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3. MONTHLY AVERAGE FIELDS(Fig.1)

The heavy rainfall areas are in equatorial latitudes associated with the strong convection in the ITCZ and SPCZ. Especially noteworthy are the high values of precipitation in South America, Africa, and Maritime Continent and in the equatorial Pacific Ocean. Moreover, there are high precipitation areas in India and southeast Asia, mainly due to the Indian and Asian monsoons.

The highest values of evaporation occur over the subtropical oceans called as the oceanic deserts. However, the high evaporation area has the center in the eastern part of South Pacific, while that has the center in the western part of South Atlantic. Moreover, the evaporation over the relatively warm current such as Kuroshio and Gulf Stream is high. We can distinguish these high regions east of the two major continents from the ocean deserts in this figure. It is not the case in previous climatological maps (e.g., Baumgartner and Reichek,1975). Also the values of evaporation are considerably large compared with climatological values.

The feature of freshwater flux field is quite similar to that of precipitation field, qualitatively, though the values are decreased by the effect of evaporation.

4. MERIDIONAL PROFILES OF THE ZONAL-MEAN VALUES (Fig.2)

We can see remarkable interannual variation for the meridional profile of precipitation. Though the peak in the southern hemisphere is generally very small compared with that in the northern hemisphere (e.g., Peixoto and Oort, 1992), the peak in the southern hemisphere has a same amplitude as that in the northern hemisphere in 1998. The high precipitation is closely related to the development of SPCZ.

5. TIME-LATITUDE SECTION OF EACH FLUX AVERAGED OVER THE LONGITUDINAL BAND (Fig.3)

The most significant feature is high precipitation between 0˚ to 10˚ S in the first half of the year 1998. This feature which affects large fresh water flux there, is closely related to the development of SPCZ which seems to be caused by the 1997-1998 El Nino event. Interannual variations of precipitation in the northern hemisphere and of evaporation are not so remarkable.

6. EOF ANALYSIS

6.1 Precipitation(Fig.4)

EOF 1 shows seasonal variation which has a positive peak from January to February and a negative peak in August. EOF 1 exhibits high precipitation in the summer hemisphere independent of land and ocean. EOF 2 shows seasonal variation which has a positive peak from April to May and a negative peak from November to December. The amplitudes of the positive peak and the negative peak are large and small in 1998 compared with other years, respectively. EOF 2 is basically Pacific mode. The center is located on the equator. However, it is suggested that the link between equatorial Pacific Ocean and other tropical regions such as southeast Asia exists. EOF 3 seasonal variation which has a positive peak from August to September and a negative peak from May to June. However, the peak is extremely large in January 1998. The spatial pattern of EOF 3 is similar to that of EOF 2. However, the link between equatorial Pacific Ocean and other tropical regions cannot be found in this mode.

6.2 EVAPORATION (Fig.5)

EOF 1 shows seasonal variation which has a positive peak from December to January and a negative peak in July. The positive peak in December 2000 is fairy large. EOF 1 shows large amplitudes in mid-latitudes, in particular east of Japan. It is interesting that the spatial pattern is extremely different from that of the average field. EOF 2 shows seasonal variation which has a positive peak from March to April and a negative peak from September to November. The distribution depends on latitudes and shows anti-symmetric mode about the equator. EOF 3 shows semiannual variation. The spatial scale is relatively small compared with other modes. Since the high values exist over Arabian Sea, Gulf of Bengal, western North Pacific and western North Atlantic, EOF 2 is closely related to Monsoon.

6.3 FRESHWATER FLUX(Fig.6)

Since EOF 1 shows similar variation to EOF 1 for precipitation, the mode seems to be affected by precipitation. It is interesting that time of the positive peak is different depending on the year. The mode is considered to show linkage among ITCZ, SPCZ and maritime continent. EOF 3 shows seasonal variation which has a positive peak from August to October and a negative peak from April to June. It should be noted that the period of negative values is remarkably short. The spatial pattern strongly depends on latitudes.

7. CONCLUSION

Precipitation, evaporation and freshwater flux are estimated based on satellite data. The data used in this study are monthly mean fields for the period from 1998 to 2000. The spatial distribution of evaporation is relatively stable, while that of precipitation shows remarkable interannual variability strongly related to development of SPCZ in 1998, which seems to be linked with 1997-1998 El Nino. As a result, spatial variability of freshwater flux over the ocean is affected by not evaporation but precipitation. EOF analysis is applied to isolate dominant patterns of precipitation, evaporation and freshwater flux. The first three modes show seasonal variation except the third mode of evaporation. EOF 1 of precipitation and freshwater flux exhibits high values in the summer hemisphere independent of land and ocean. EOF 1 of evaporation shows seasonal variation which has a positive peak from December to January and a negative peak in July. The positive peak in December 2000 is fairy large. This mode shows large amplitudes in mid-latitudes, in particular east of Japan. It is interesting that the spatial pattern is extremely different from that of the average field.

References

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(a) (b) (c)

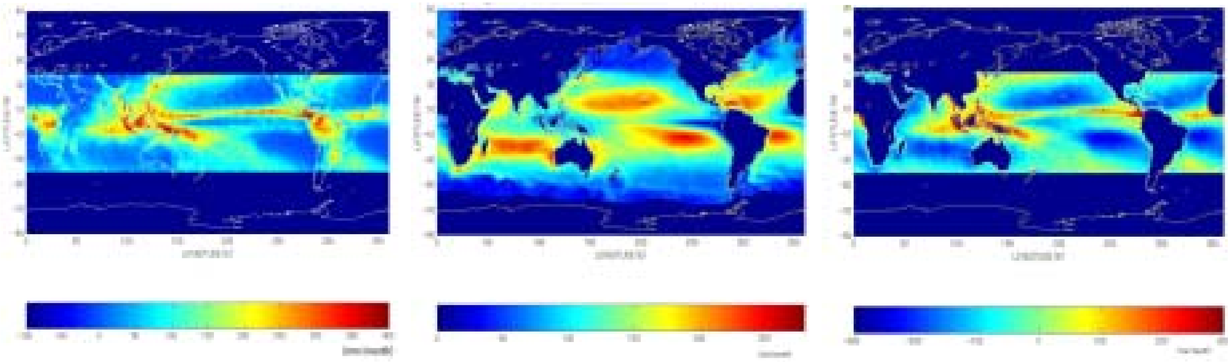

Fig.1 Monthly average fields (1998-2000). (a) precipitation, (b) evaporation, and (c) freshwater flux.

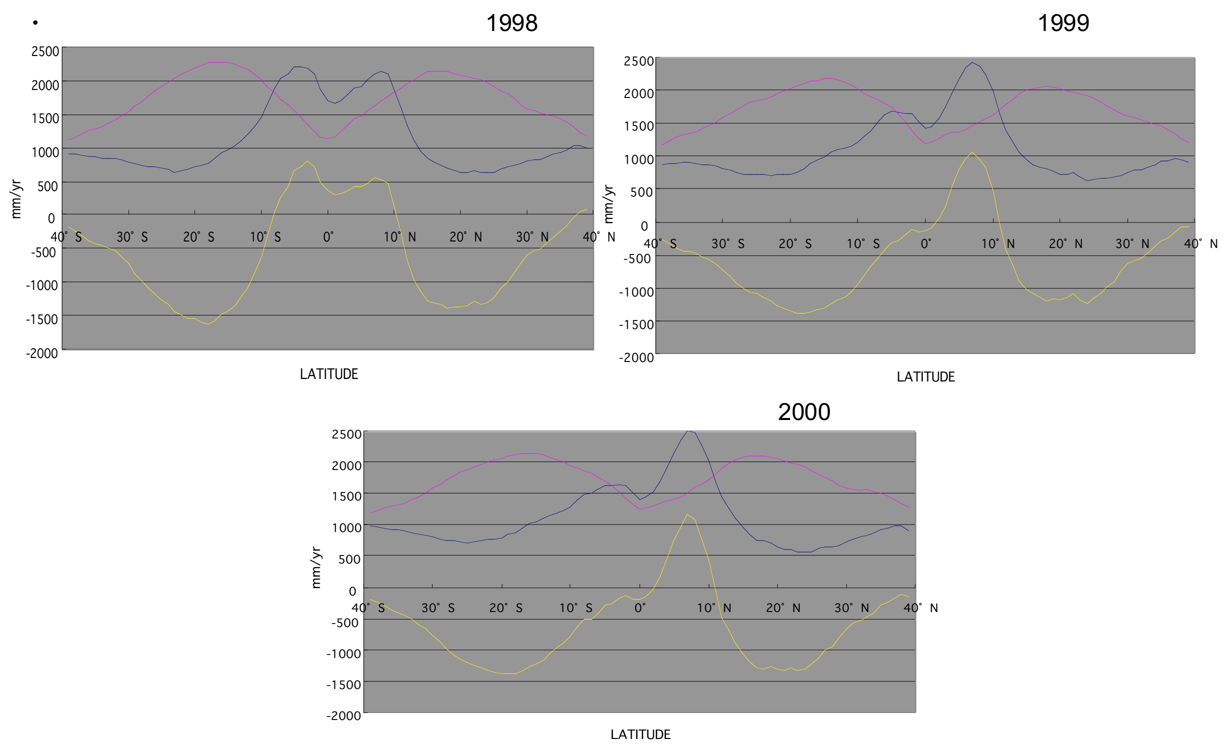

Fig.2 Meridional profiles of the zonal-mean precipitation(blue), evaporation(red) and freshwater flux(yellow).

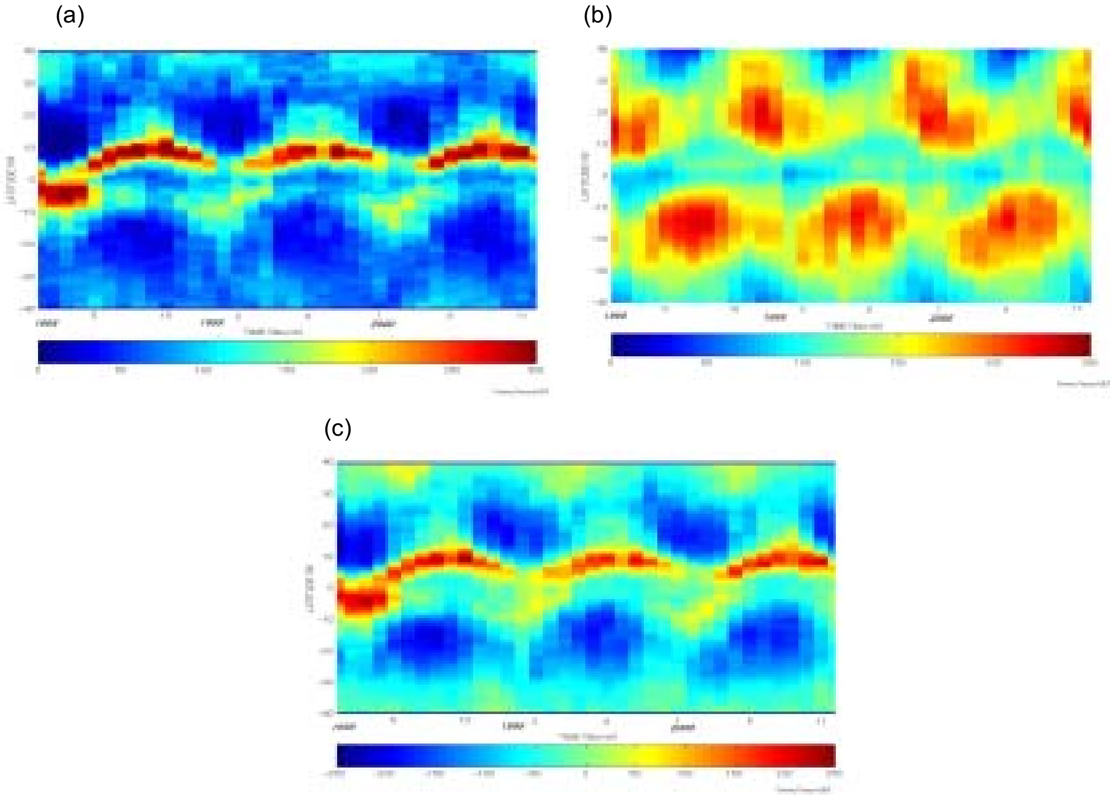

Fig.3 Time-latitude section of (a)precipitation, (b)evaporation and (c)freshwater flux averaged over the longitudinal band.

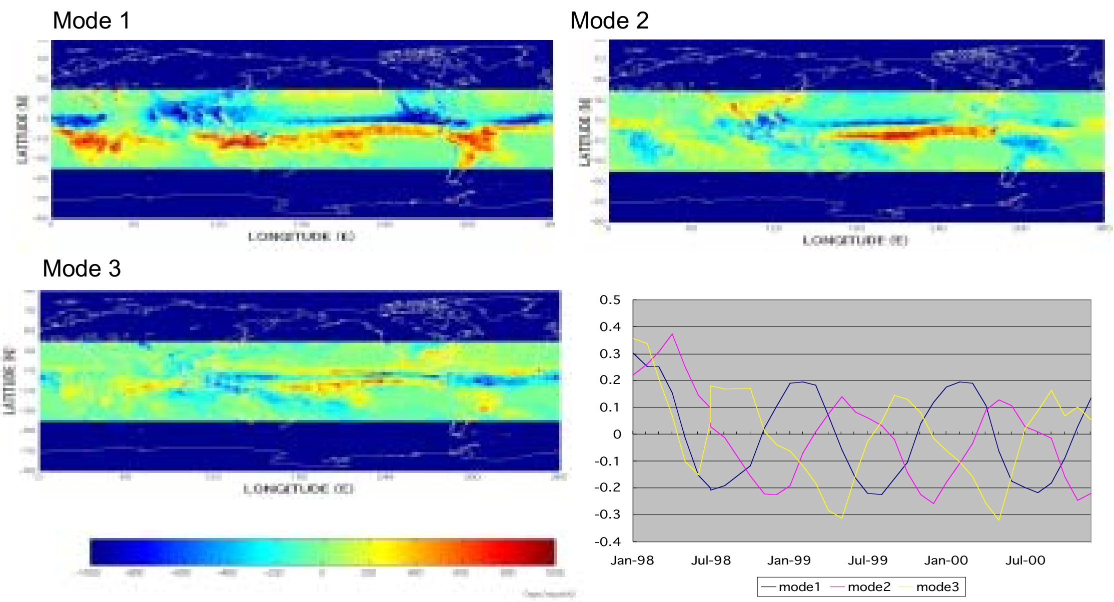

Fig. 4 First three EOFs of precipitation in the tropical regions. A right lower panel: Temporal coefficients of first three EOFs.

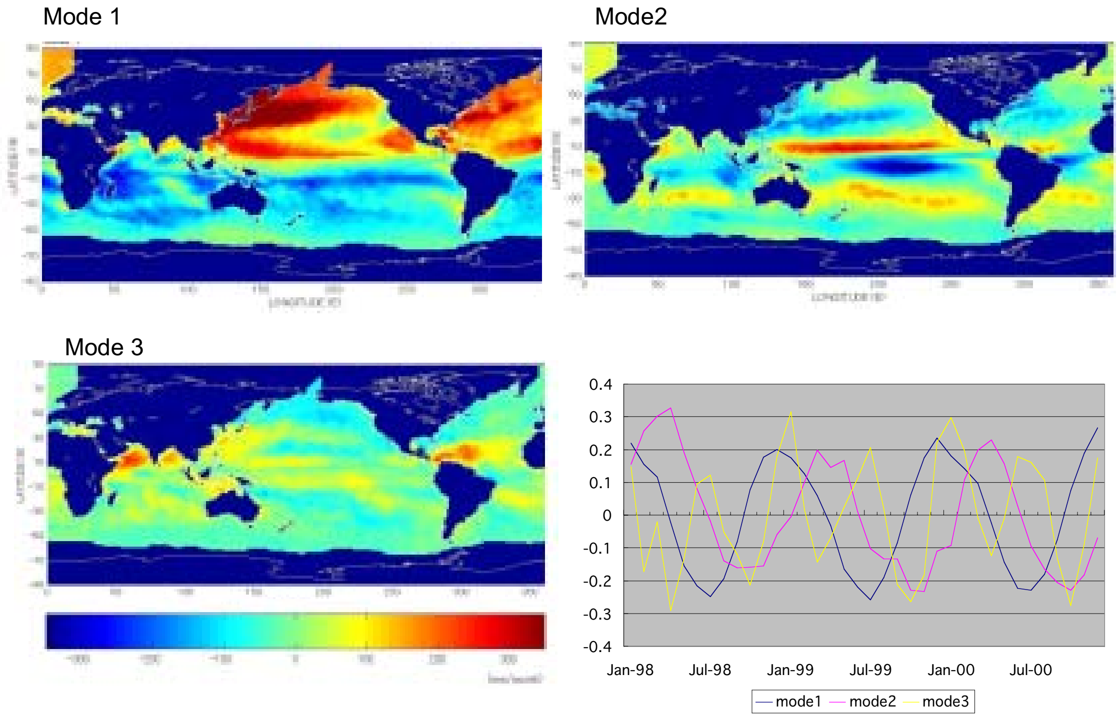

Fig. 5 First three EOFs of evaporation in the tropical regions. A right lower panel: Temporal coefficients of first three EOFs.

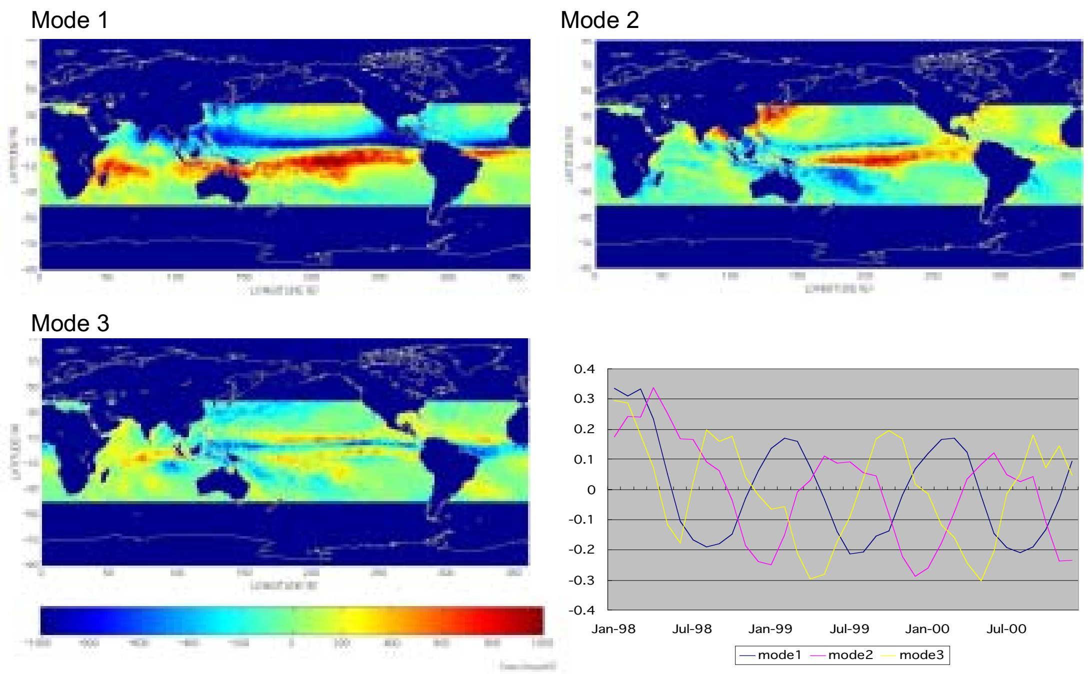

Fig. 6 First three EOFs of freshwater flux in the tropical regions. A right lower panel: Temporal coefficients of first three EOFs.